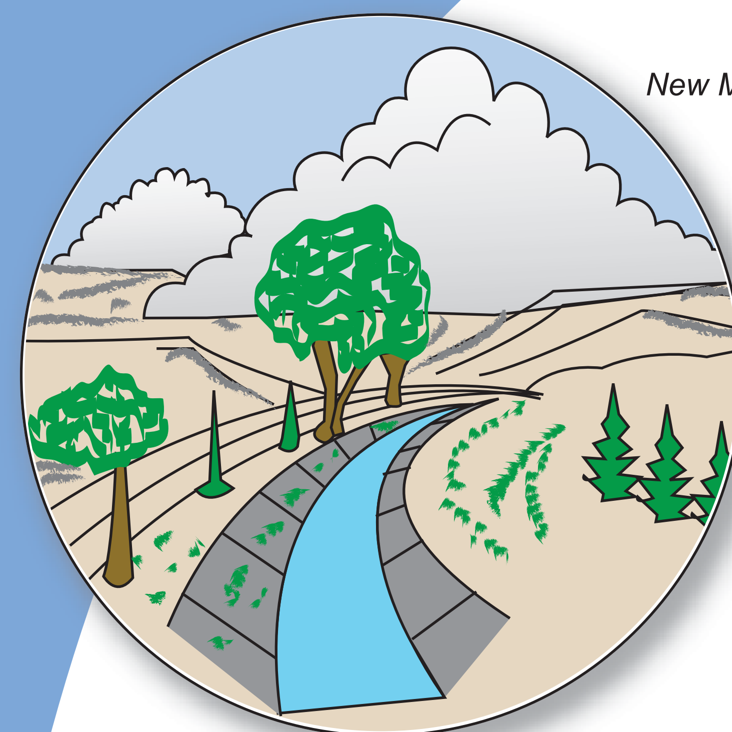
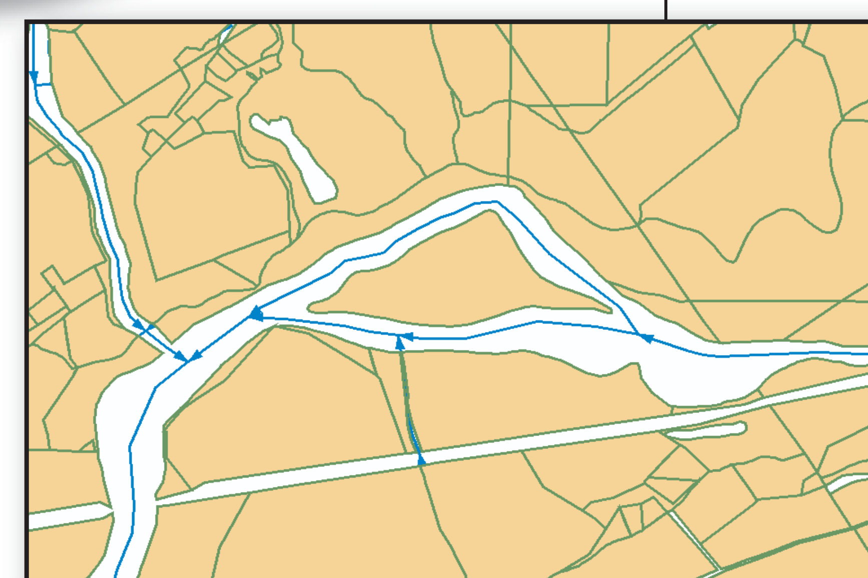
Inception Report

Acequia Geographic Information System

Office of the State Engineer / Interstate Stream Commission (OSE/ISC)
In cooperation with
U.S. Army Corps of Engineers
New Mexico Office of Cultural Affairs, Historic Preservation Division
National Resource Conservation Service





KnowledgeSystems&Solutions

August 30, 2002

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ACEQUIA GEOGRAPHIC INFORMATION SYSTEM (AGIS)

INCEPTION PHASE REPORT
State of New Mexico

Prepared for
Office of the State Engineer / Interstate Stream Commission (OSE/ISC)
In cooperation with
U.S. Army Corps of Engineers
New Mexico Office of Culture Affairs, Historic Preservation Division
National Resource Conservation Service

August 30, 2002

Prepared by
Weston Solutions, Inc.
Knowledge Systems and Solutions

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TABLE OF CONTENTS

TABLE OF CONTENTS *(Continued)*

LIST OF FIGURES

LIST OF TABLES

SECTION 1

INTRODUCTION

1.1 PURPOSE

The purpose of this inception report is to provide a conceptual design and vision for implementing a multi-agency acequia geographic information system (AGIS). The AGIS is envisioned to be a web-based, shared repository for acequia-related information. This system will be used to facilitate management, preservation, and engineering activities related to acequias and associated communities.

This inception phase is the initial step in a multi-phase approach. The purpose of this inception report is to provide sufficient information, at the minimum possible cost, to allow the New Mexico and Federal participants to determine if they should proceed with the next phase of this project.

The major objectives of the next phase (elaboration) are to provide a detailed system design, develop a prototype project, and define the project with sufficient detail to provide accurate cost estimates for the remainder of the project.

1.2 PARTICIPANTS

This inception report was prepared for the New Mexico Office of the State Engineer / Interstate Stream Commission (OSE/ISC) in cooperation with the U.S. Army Corps of Engineers (COE), the New Mexico Office of Culture Affairs, Historic Preservation Division (HPD), and the National Resource Conservation Service (NRCS). The Knowledge Systems and Solutions Group (KS2) of Weston Solutions, Inc. (Weston) conducted interviews (see Appendix A) researched relevant records, provided the analysis, and prepared this report.

1.3 REPORT ORGANIZATION

This plan is organized into six sections. The remaining sections are:

- Section 2 (Project Overview) identifies the critical aspects of an acequia, describes the GIS technology, and illustrates generic benefits that are attributable to an AGIS.
- Section 3 (Current Systems) identifies the relevant current systems.
- Section 4 (Data and Application Requirements) evaluates the existing geographic data resources and identifies needed improvements to existing data.
- Section 5 (Conceptual Design) provides a conceptual architecture for the proposed AGIS.
- Section 6 (Implementation Plan) recommends an implementation approach, budget, and schedule for system development.

SECTION 2

PROJECT OVERVIEW

This section identifies the relevant aspects of an acequia, describes the GIS technology, and illustrates generic benefits that can be derived from an AGIS.

2.1 GEOGRAPHIC INFORMATION SYSTEMS

A Geographic Information System (GIS) can be defined as an information system with geographic or spatial content. Approximately 80 percent of a typical state's information is related to a geographic feature of some sort, such as a ditch, water right, place of use, and archeological / cultural sites.

Information systems that manage spatial information can be integrated through the use of GIS technology. A GIS provides a system of software, automated maps, and databases that contain information about map features. With proper planning and design, the acequia resources can be viewed and analyzed in the form of maps.

A GIS is not simply a computer system for making maps. It is a sophisticated management and analysis tool that allows the user to identify the spatial relationships among map features. There are five generic questions that a well-designed GIS can answer.

- Location—What is at a given location?
- Condition—Where is it?
- Trends—What has changed over time?
- Patterns—What spatial patterns exist?
- Modeling—What if ...?

An example of each of these questions is provided below.

Location—What is at a given location

Data management is simplified when the user can quickly find out what exists at a particular location. The location can be described in many ways including place name, water right number, stream system, address, geographic coordinates, other attributes, or by pointing to the feature on a computer screen. For example, as illustrated in Figure 2-1 (Location Example), a user could quickly zoom to a geographical area of interest to view all available data. Options for zooming could be acequia name, county, groundwater or river basin, and/or Public Land Survey System parameters.

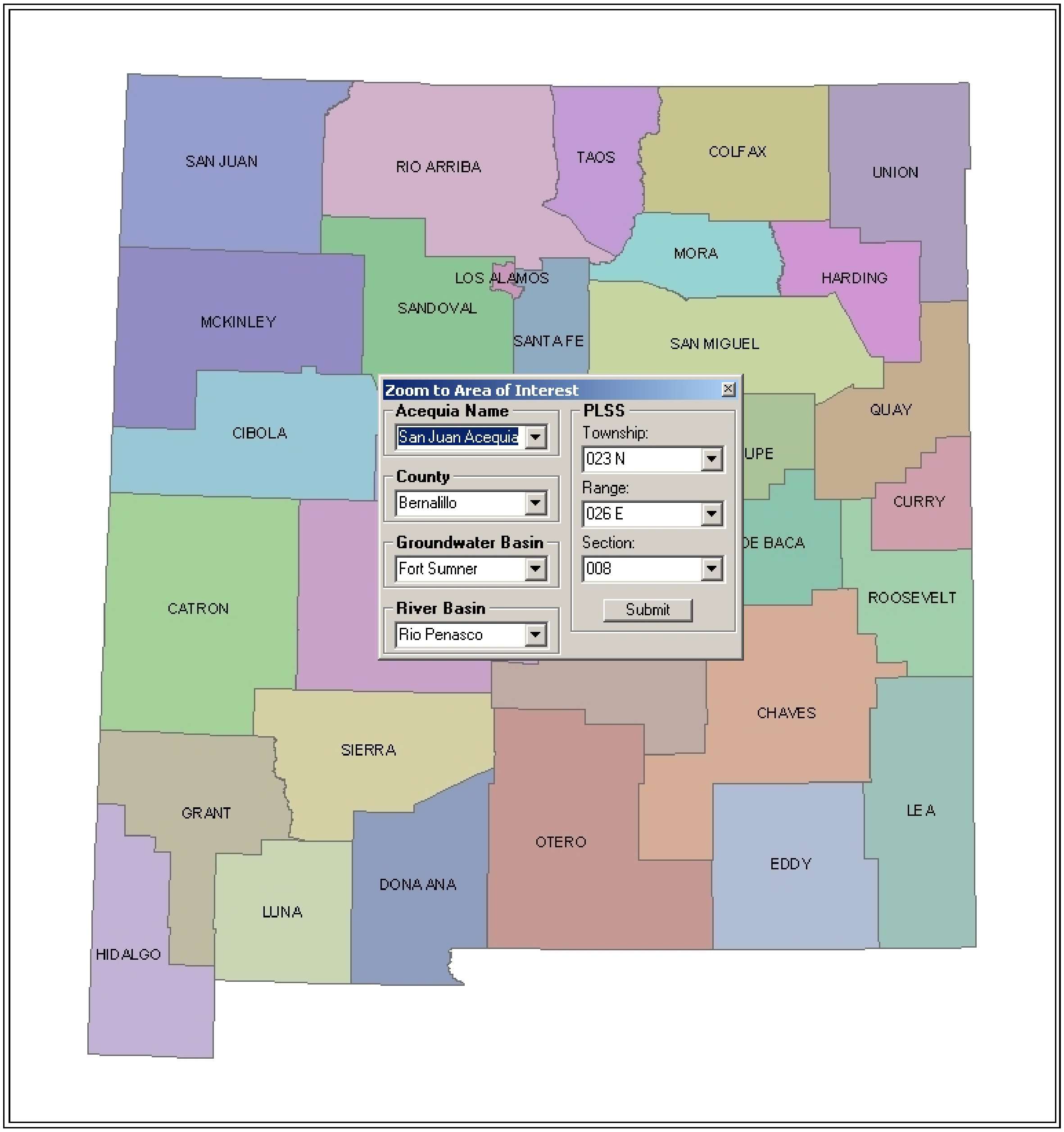


Figure 2-1—Location Example

Condition—Where is it?

This question is the reverse of the location question. Instead of identifying what exists at a given location, the user asks the GIS to show locations where certain conditions are satisfied. For example, a user could show all acequias with planned rehabilitations and highlight those that are also on the historic register as illustrated in Figure 2-2 (Condition Example).

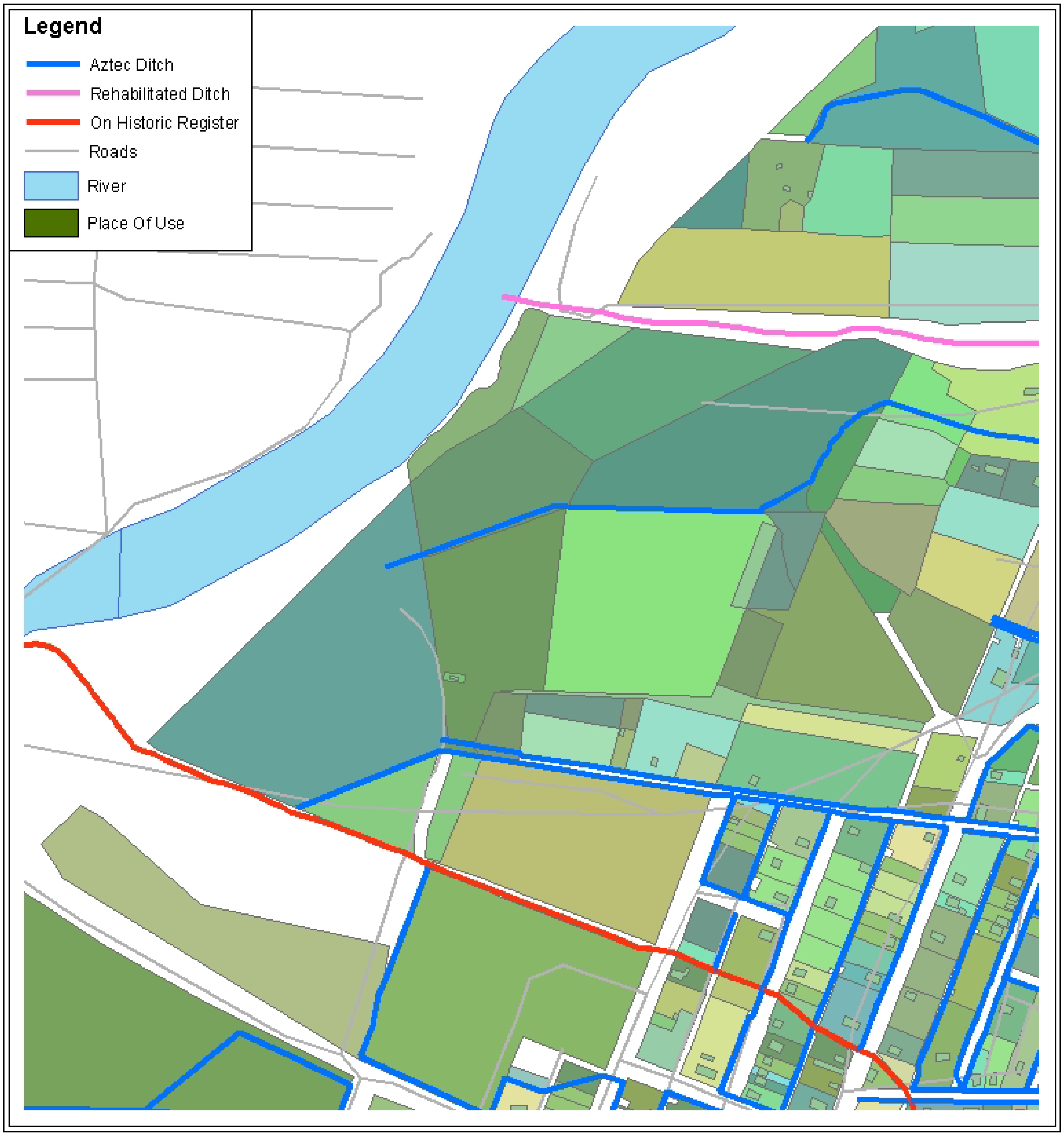


Figure 2-2—Condition Example

Trends—What has changed over time?

This question can involve either location or condition and seeks to display changes over time. For example, the user could show the distribution of acequias that have not been used in the last 50 years, as illustrated in Figure 2-3 (Trend Example). The polygons in Figure 2-3 represent hydrologic catchments.

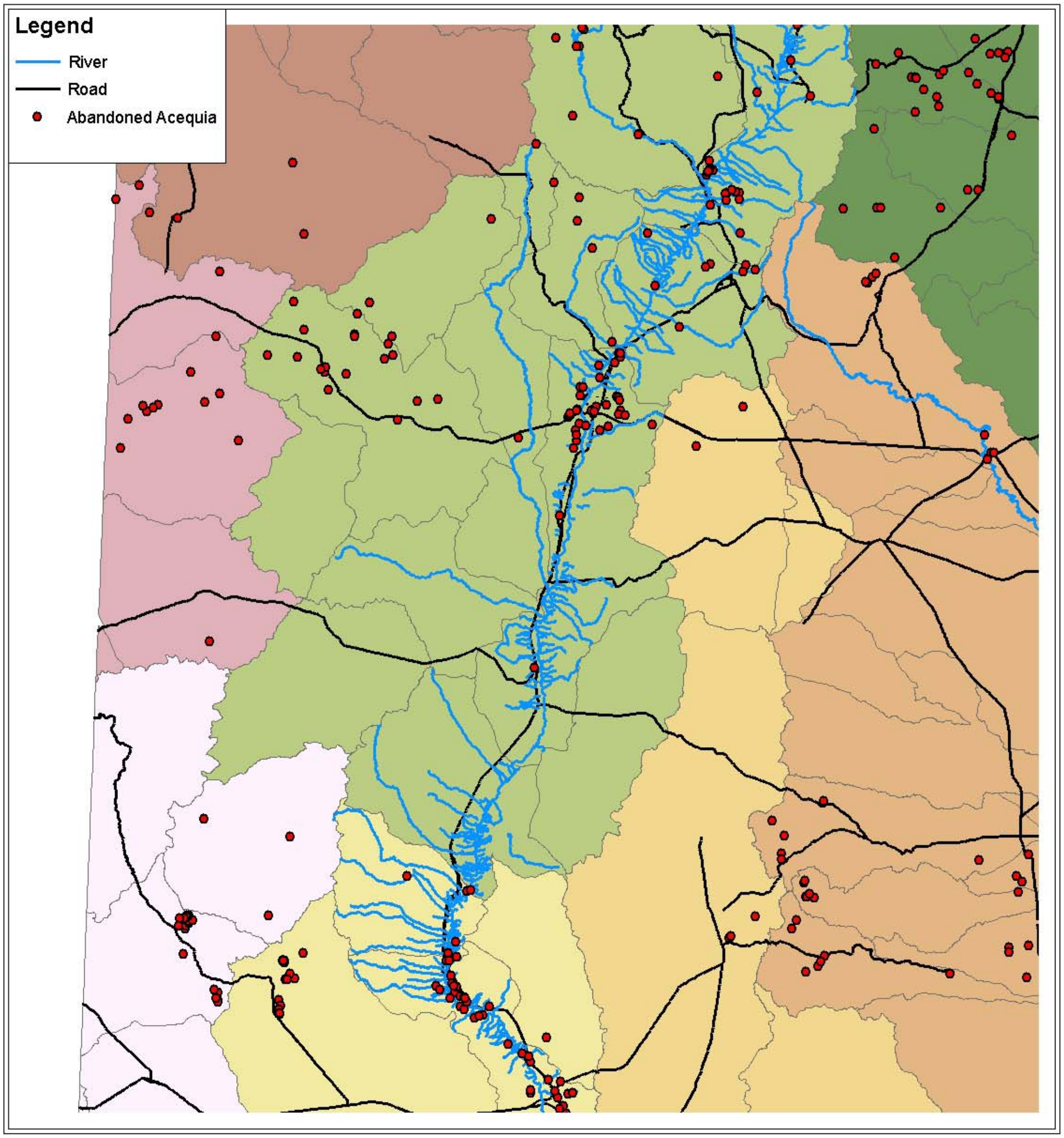


Figure 2-3—Trend Example

Patterns—What spatial patterns exist?

These types of questions can be rather simple (involving a small number of variables) or be quite complex (and include many different parameters). A simple query, for example, could involve the display of acequia densities in New Mexico by drainage basin as illustrated in Figure 2-4 (Patterns Example). This example has used actual data from Ackerly (1996).

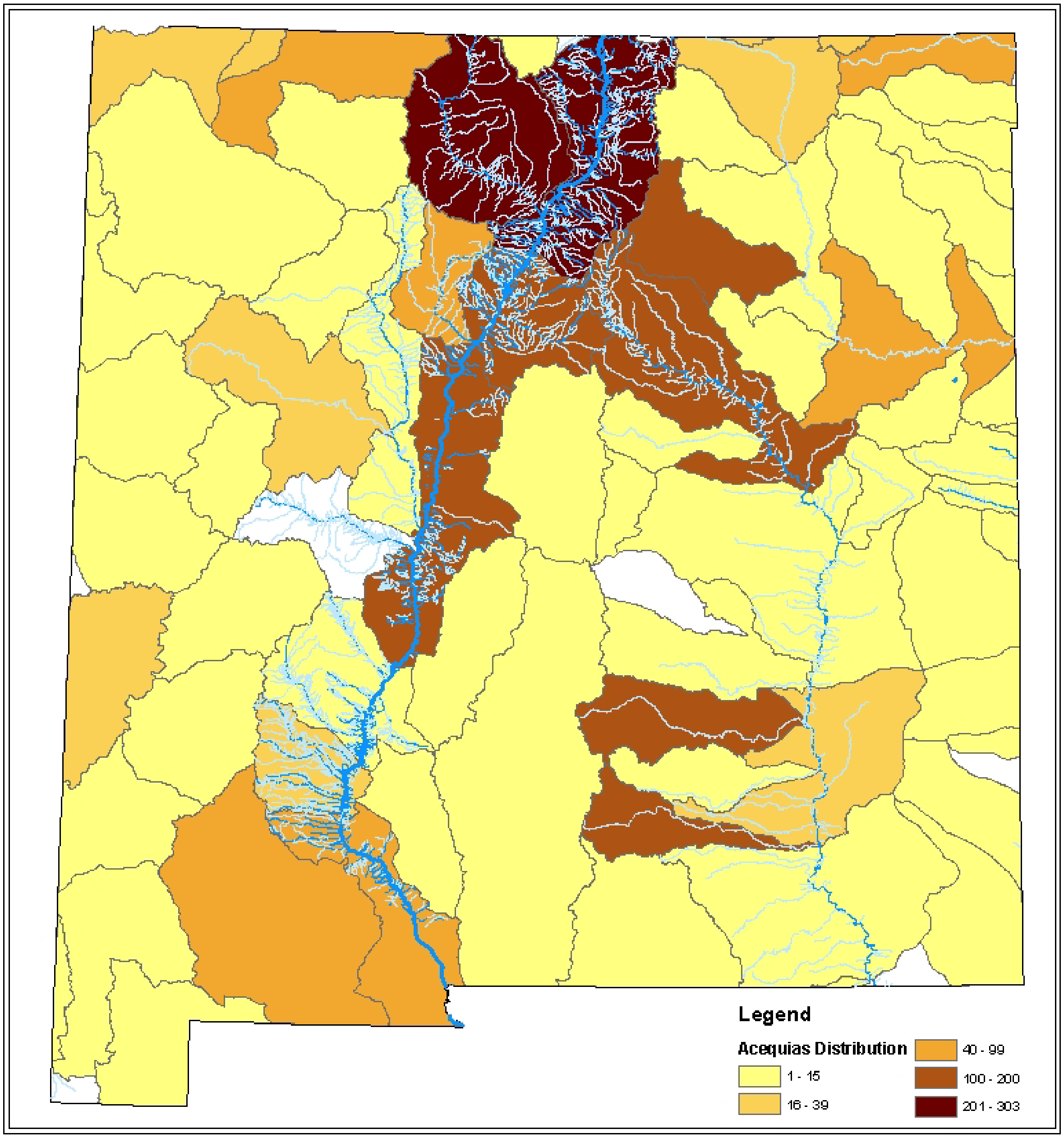


Figure 2-4—Patterns Example

Modeling—What if …?

These types of questions are posed to predict the consequences of proposed changes. For example, which acequias would be affected by a proposed land development project, as illustrated in Figure 2-5 (Modeling Example). In this example, all acequias on the historic register and with a buffer zone of a proposed road are queried to identify any potential conflicts of the proposed development.

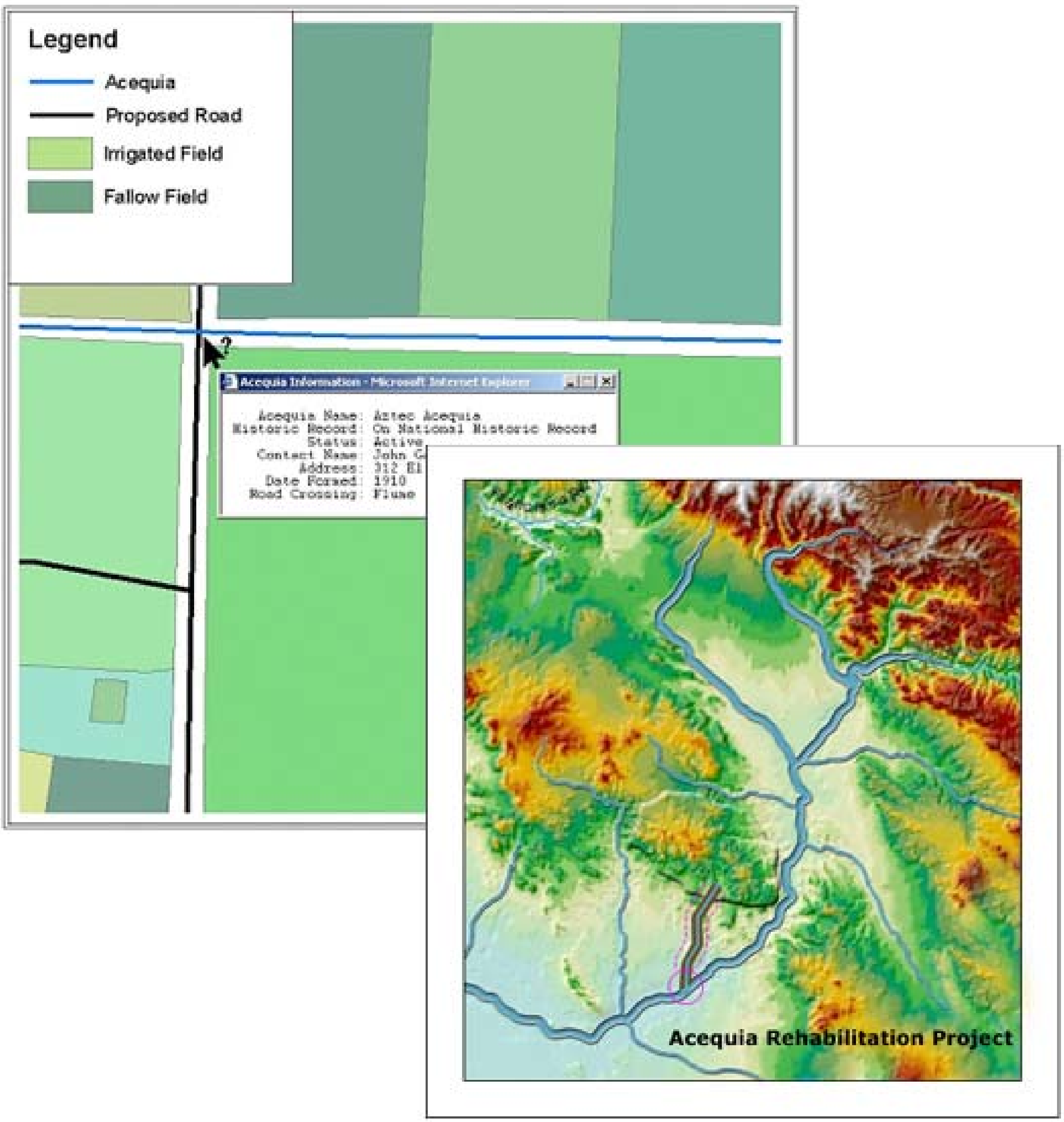


Figure 2-5—Modeling Example

2.2 RELEVANT ACEQUIA CHARACTERISTICS

2.2.1 History

The origin of acequias in New Mexico has been traced to Pueblo Indians and Spanish settlers. The Pueblo Indians were reported to have been practicing irrigation farming when Spanish explorers first came to the region in the 1500s. The Spanish settlers brought with them irrigation experience developed in Iberia during the later prehistoric, and particularly the historic (i.e., Moorish), periods. They combined their customs and knowledge with those of the pueblos, resulting in the unique institution of the acequia or community ditch (NMOSE 1997: 4).

New Mexico has approximately 800 community acequia and ditch associations registered with the OSE/ISC. A 1996 investigation by Ackerly found at least some information for 1,927 acequias that once operated or might still be operating (Ackerly 1996: 4). The same investigation identified 2,048 existing and historic ditches. Figure 2-4 (Patterns Example) shows the distribution of acequias by surface water basin. Most are located in the north central portion of the state in Mora, Rio Arriba, Santa Fe, San Miguel, and Taos counties. The farms served by acequias range in size from less than one acre to more than 500 acres; the majority are less than 20 acres (OSE 1997). The lengths of the acequia ditches vary, but most are on the order of one to two miles. Of course, large conservancy / irrigation districts have considerably more miles of ditch. The Middle Rio Grande Conservancy District, for example, has nine main canals aggregating 202 miles in length, plus 579 miles of subsidiary lateral canals, and 399 miles of drains (WPRS 1981: 623).

2.2.2 Acequia Definition

An 'acequia' can be defined in a physical, political, and legal context. As a physical structure, an acequia or community ditch is typically a man-made, open, unlined, channel that conveys water to individual tracts of land. As a political organization, an acequia is a public entity that functions to allocate and distribute irrigation water to the landowners who are its members. Finally, from a legal perspective, an acequia pertains to ditches which are not private or incorporated under the laws of the State and which are owned by three or more persons as tenants in common.

The physical characteristics of an acequia, or ditch, typically include a diversion dam and headgate, a main ditch channel commonly called the *acequia madre*, lateral ditches leading from the main channel to irrigate individual parcels of land, and a wasteway channel that returns surplus water from the ditch system back to the stream. Occasionally, the system includes a storage reservoir or trans-basin ditch. The diversion structures can be built of readily available materials, such as timber, brush and rocks, or consist of concrete and masonry. The channels usually operate by gravity flow.

The community acequia, or ditch association, is composed of owners of the lands irrigated by a ditch. Landowners are assessed dues by the acequia association for the operation, maintenance, and improvements to the ditch system. Three commissioners and a *mayordomo*, elected by association members, manage the allocation and distribution of irrigation water, and all members participate in acequia maintenance (Wilson 1997).

2.2.3 Selected Legal Factors

The laws that govern acequias developed from Spanish, Mexican, and Native American customs and traditions as modified by legislation and court decisions. This subsection provides a brief summary of the laws and legal decisions that have been considered in the conceptual design of the AGIS. Note that this is NOT a comprehensive legal analysis.

The Territorial Legislature provided that the course of ancient acequias, established prior to July 20, 1851, shall not be disturbed (NMSA 1953: Section 75-14-60, Laws 1851-1852). The Territorial Supreme Court held that this section was enacted primarily for the protection of ditches from trespasser and was intended as a guarantee against the destruction and disturbance of construction after 1851 (Candelaria vs. Vallejos 1905: 13 NM 146, 164).

Any acequia, or community ditch association, has the power to acquire, use, and transfer property and water rights (NMSA 1953: 73-2-22.1.).

The laws recognize acequias as political subdivisions of the State and as such, under the power of eminent domain, they can condemn land for the construction of ditches. Of course, private property cannot be taken for a ditch without just compensation (NMSA 1953: 75-14-25.1). The laws also recognize that an acequia association has an easement on the land upon which the acequia is located if it has been used continuously for irrigation for five or more years. The owner of the land can change the location of the ditch on his land provided written agreements do not preclude the change or the change does not interfere with its use by the owners of the acequia (NMSA 1953: 75-14-5).

Unless a specific easement has been agreed to in writing between the landowner and the acequia, the width of the easement is subject to interpretation. The general legal rule is that the easement is defined by the physical ditch and the historical width used for maintenance on both sides of the ditch. The acequia can make no changes in the easement dimensions or use without the landowner's consent (Posey vs. Dove 1953: 57 NM 200,212,214).

Acequia associations are required to construct bridges whenever the ditch crosses a public road (NMSA 1953: 55-6-7 and 55-6-9, Laws 1917).

2.3 BENEFITS

Implementing an Acequia GIS will enable the acequias, State, and Federal partners to make more efficient use of resources, improve service delivery, and provide more responsive policy decision support.

Many benefits, like improved service and decision-making, are intangibles. An analogy can be drawn to the telephone system, which, when it was first introduced, was difficult to justify in dollar terms. What is the savings of being able to call someone on the phone and answer a question in minutes versus writing a letter and waiting for the response? A long distance call is more expensive than writing a note and postage, but few would disagree that the phone call is less expensive when the value of a timely response is considered. In addition, as the cost of phone calls is reduced, the tangible benefits of the phone system are also improved.

The benefits of multi-agency information systems can be grouped into three broad areas of concern to the participants. These benefits are:

1. More efficient use of resources
2. Improved service delivery
3. More responsive policy decision support

2.3.1 More Efficient Use of Resources

Use of multi-agency information systems results in more efficient utilization of the participant's resources. There are three major areas of efficiency benefits that can be realized: cost sharing, productivity enhancement, and cost avoidance.

2.3.1.1 Cost Sharing

Sharing the cost of system implementation across multiple agencies is a popular approach nationwide. The long-term cost of coordinated system implementation is likely to be less than that of several individual, uncoordinated departmental efforts.

Several of the participating agencies are already using GIS capabilities in response to their need for improved productivity. Some of these activities are informally coordinated, but there is no strategic plan or design to ensure that they will efficiently and effectively share data. The costs required to more formally coordinate these ongoing activities will result in significant savings in long-term operating costs.

2.3.1.2 Productivity Enhancement

Productivity enhancements are expected to occur whenever a new technology is appropriately applied. In the case of the AGIS, significant productivity enhancement can be expected among mayordomos, commissioners, planners, engineers, and other personnel who are heavily involved in decision-making activities that require spatial data. These enhancements result from quickly obtaining required information. Even if each individual only saves a few hours each week obtaining data, the cumulative time saved by many users becomes significant.

Use of a GIS can liberate professionals from collecting, compiling, and reconciling geographic information so they can spend more of their time practicing their disciplines. As staff is able to handle more work through efficient data retrieval, the organization is able to eliminate backlogs and perform additional tasks. This can help an organization avoid future staff increases. Another typical occurrence is that users are able to leverage the improved access of information resulting in better project planning. By considering more alternatives for an acequia project plan, for instance, an engineer will be able to reduce design, construction, or operating costs.

Even a small increase in productivity per affected employee will result in dramatic productivity enhancement given the large number of potential users.

As an example, the New Mexico State Historic Preservation Office consults with at least three federal agencies concerning Section 106 compliance on acequias throughout New Mexico. In every case, the consultation process requires an assessment of cumulative agency actions on a given acequia system and an assessment of the historic integrity of the system (i.e., National Register of Historic Places). An AGIS would provide a practical way of recording and managing this kind of information, saving all consulting parties a significant amount of background research. Additionally, the visual impact of the proposed action (usually a ditch lining or piping project) is taken into consideration within larger historic districts. Here again AGIS will provide a means of assessing impact without field visits by either consulting party.

2.3.1.3 Cost Avoidance

Cost avoidance can be defined as minimizing future capital or operating expenditures. Use of an AGIS can help avoid a number of costs, particularly in the area of infrastructure management.

The productivity enhancements among design engineers, which allow them to spend less time compiling information and more on design, coupled with improvements in analytic capabilities made possible through use of an AGIS, can help ensure that major public works facilities are properly sized. This translates into avoidance of over-building or premature expansion costs.

Analysis of existing infrastructure maintenance and failure data can be used to optimize decisions about capital replacement.

Data on the same variables collected for different purposes often look very different, which can be a problem, especially in litigation. Litigants want the data they present to the court to be consistent, defensible, and explainable. An AGIS will facilitate the reconciliation of conflicting data.

2.3.2 Improved Service Delivery

With technological advancements come increased service delivery expectations among the citizens. If citizens receive immediate, consistent answers to service questions, because staff have improved access to shared information, they will correctly perceive the agencies to be responsive to the citizens' needs.

A measure of an information system's success is the extent to which it fosters better decisions based on more timely, accurate, and complete information. Better operational and management decisions are the only practical way to achieve service improvements without increasing budgets.

A survey of acequias by Ackerly (1996: 142) found that 74 percent of the acequia associations polled indicated that knowing the history of their ditch was "very important" and two-thirds of the associations expressed a desire to have the history of their acequia preserved. One of the driving purposes of the AGIS is to collect and make this kind of information readily available.

2.3.3 More Responsive Decision Support

Decision makers face an increasingly complex array of competing interests and demands of constituents while having to cope with more Federal- and state-mandated activities. Coordinated GISs increase the timeliness and accuracy of decision support information required by policy bodies. Most decisions must be made in a brief time frame. The ability to make an informed decision is partially a function of having reliable data in a usable format when it is needed. Most organizations that have developed a GIS consider this decision support function to be the most valuable benefit. Improved decisions significantly improve an organization's effectiveness, efficiency, and reputation.

SECTION 3

CURRENT SYSTEMS

The current systems are defined in terms of relevant inputs, processes, and products that would directly interact with the proposed AGIS.

3.1 OFFICE OF THE STATE ENGINEER

The Office of the State Engineer (OSE) and the Interstate Stream Commission (ISC) are separate but companion agencies charged with administering the state's water resources. Together the OSE and the ISC are responsible for the administration, investigation, planning, development, conservation, and protection of New Mexico's water resources. The two agencies described their joint mission in the agency's strategic plan to "actively manage the state's water resources through the lawful allocation, development, and administration of the state's water for beneficial use within the state for the benefit of the people of the State of New Mexico."

Specific to acequias, the OSE administers water rights and performs adjudications (includes conducting hydrographic surveys). The ISC administers the Irrigation Works Construction Fund (IWCF). The IWCF funds are used to make loans to acequias and irrigation and water conservancy districts for construction and rehabilitation of irrigation works. The IWCF provides technical assistance on design improvements for acequias through an annual contract with the NRCS. The IWCF is also a source for the non-federal cost-share required by the USACE Acequia Program.

3.1.1 Water Administration Technical Engineering Resource System

The Water Administration Technical Engineering Resource System (WATERS) is a transactional system that tracks water-right applications from the time they are received to their approval or disapproval. The system also tracks approved applications to the final disposition of the permit. It contains all information relevant to each application, including the amount of water to be appropriated, the source of the water, the use of the water, the water right priority, the location (non-graphical) of the works or well, details of the construction of the surface works or well, the name of the well driller, and details on the water source, such as the depth to water in a well. The existing system has a character based user interface and is written in Informix 4GL programming language. The system uses a two-tier architecture.

An upgraded WATERS, called eWATERS, is under development. The eWATERS architecture can be summarized as a web-based, thin client, multi-tier system. The following IT infrastructure is being used to implement the system:

a) **User Interface:** The eWATERS application is a HTML user interface, which is compatible with Internet Explorer and Netscape Navigator. Java Server Pages and Java Servlet technology are used for the presentation layer.

b) **Application Server:** BEA Systems Web Logic Server is used as the application server as well as Enterprise Java Beans (EJB) container.

c) **Database Software:** OSE is currently using Informix Dynamic Server 9.2 running on HP_UX. This software will not change.

d) **Web Server:** Internet Information Server 4.0 is used for Internet access of the application.

e) **Programming Languages:** The main languages and development environments are:

— Java (Web Gain Studio) is used for the development of all components in the application model and domain model.

— Java Script (Dream Viewer) is used for scripting and user interface level validations.

f) **Other Technologies:** To support the proposed n-tier architecture the following other technologies are include:

— EJB technology is used to build components in the domain model layer.

— Java Server Pages (JSP) technology is used for communication among the presentation layer, application model layer, and domain model layer.

— Java Servlet technology is used for communication among presentation layer, Application model layer, and domain model layer.

3.1.2 Enterprise Geographic Information System

The Enterprise Geographic Information System (EGIS) is a data warehouse that combines WATERS transactional data with the many other data sources OSE/ISC staff rely on, inside and outside the agency, to provide all OSE/ISC staff with a common source of data. The EGIS consists of an ESRI Geodatabase using Spatial Data Engine (SDE) with Informix 9.2. The EGIS design contains all of the tables identified for the proposed AGIS, except for the cultural resource data (to be supplied, by HPD) and the image/documentary data (to be supplied, perhaps, by the USACE).

EGIS data loading is underway and follows the population of WATERS. Reference features (e.g., transportation, National Hydrographic Data Set, dams, meteorology, geology, administrative boundaries, generalized land use and cover, generalized vegetation, and 5-meter satellite imagery) have been populated statewide. The remaining reference features (e.g., public land surveys, digital elevation model, and digital orthophotography) are being loaded by groundwater basin as the basin's water rights data (i.e., Places of Use, Points of Diversion, and conveyances) are converted and entered into EGIS.

The EGIS conversion is underway for the following groundwater basins:

- Fort Sumner
- Roswell Artesian
- Hondo
- Rio Penasco
- San Juan

The following groundwater basins have been recently adjudicated with digital hydrographic surveys that can be loaded in the EGIS.

- Lower Rio Grande
- Nutt-Hockett
- Portions of Carlsbad

Planning for populating the remaining groundwater basins is underway.

3.2 CORPS OF ENGINEERS

The United States Army Corps of Engineers (USACE) provide quality, responsive engineering services to the nation including:

- Planning, designing, building and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, etc.).
- Designing and managing the construction of military facilities for the Army and Air Force (Military Construction).
- Providing design and construction management support for other Defense and federal agencies (Interagency and International Services).

The Albuquerque District provides funding and technical assistance for the restoration and rehabilitation of acequias based on the federal Water Resources Development Act of 1986.

The USACE maintains a Program and Project Management Information System (PROMIS) to track projects. PROMIS is a secure, web-accessible database systems based on an Oracle database.

3.3 HISTORIC PRESERVATION DIVISION, OFFICE OF CULTURAL AFFAIRS

The Historic Preservation Division (HPD) of the Office of Cultural Affairs is charged, in both state and federal laws, with a broad variety of tasks, all of them ultimately intended to ensure that the historic and prehistoric heritage of the people of New Mexico is preserved for the benefit of future generations. Specific activities include:

- Maintains records of identified historic and prehistoric sites and makes those records available for research, education, and planning for future development.
- Works with property owners and interested citizens to nominate historic sites and districts to the National Register of Historic Places and State Register of Cultural Properties so that the historic significance of these places can be recognized, so that they will be considered in planning for development, and so that their owners will be eligible for preservation incentives.
- Administers state and federal rehabilitation tax credit programs, a low-interest revolving loan fund, and state and federal grant programs, all designed to provide incentives for communities and private owners to preserve their historic sites and districts.

- Provides information and technical assistance to agencies, local governments, and private owners to aid them in preserving, restoring, stabilizing, and effectively reusing historic properties.
- Develops education and outreach programs to inform the public about the value of preserving the past and to enlist their support for heritage preservation.
- Administers state and federal laws that provide protection for historic and prehistoric properties.
- Assists local governments in developing effective preservation ordinances and plans.

Specific to the AGIS, the HPD maintains an inventory of all recorded archeological sites and investigations in New Mexico. The program responsible for maintaining this inventory is known as the Archeological Records Management Section (ARMS). ARMS is the official state clearinghouse and repository for archeological records. The program is responsible for administering, managing, and preserving records pertaining to archeological properties in the State of New Mexico.

Data derived from over 70 years of archeological research was automated and has served as the primary index to the many reports, research notes, forms, maps, and other documentation relating to over 100,000 archeological sites and 40,000 inventory and excavation projects in New Mexico. The database also provided a link to many archeological collections of the Museum of New Mexico, including the Archeological Repository Collection (i.e., bulk artifact collections), and various study collections created since the Lab's beginnings in the 1930's.

In 1993, ARMS was replaced with a more comprehensive system known as the New Mexico Cultural Resource Information System (NMCRIS). All existing archeological data were converted to the new information system, but the system was expanded to also integrate records pertaining to New Mexico's historic architecture and traditional cultural properties, and to serve the needs of a broader user community that includes industry as well as government and researchers.

The NMCRIS database will be accessed locally at the Laboratory of Anthropology, or at remote locations via modem or the Internet, providing online information exchange to scholars, nonprofit groups, archeological contractors, federal and State agencies, universities, and other organizations. An individual user account is required to access the online database query facility.

Cooperative data sharing agreements with most state and federal land managing agencies provide financial support for the program and allow NMCRIS to cross lines of ownership and tie together all levels of government in an integrated statewide system of archeological data collection, management, and distribution. NMCRIS provides information to both government and private entities so that cultural resources can be considered in early stages of project planning, and damage to archaeological resources can be minimized. With NMCRIS, developers using public lands will be able to avoid some of the delay and expense that frequently accompanies archeological clearance efforts, and sites can be avoided entirely rather than excavated. The GIS capabilities of NMCRIS also enable land managers to develop predictive capabilities regarding archeological site density and visibility, and use that information to advise developers on project locations throughout the state.

The NMCRIS system is designed around an activity. An *activity* is defined as one or more archeological investigative actions (survey, excavations, analyses, etc.) conducted and reported by a single performing agency under the administrative umbrella of a project. An activity may consist of a single investigative action (a survey), or it may be a combination of several actions that are conducted and reported together by the performing agency (a survey and testing program). However, there are archeological sites that are not connected to any activity, and activities with no linkages to site excavations.

The NMCRIS is based on a three-tier architecture. The database tier, based on Windows 2000, Oracle8i and ESRI Spatial Database Engine (SDE, v. 8.1) delivers data to the application Server. The application server, based on Windows 2000, Oracle9i technology, and ESRI Internet Map Server (ARCIMS, v. 3.1), serves database and GIS applications to clients over the Internet. Finally, the client tier is based on standard Internet browser and Java technology. HPD is in the process of migrating the GIS portion of the system to an ArcSDE/Oracle geodatabase

3.4 NATURAL RESOURCE CONSERVATION SERVICE

The Natural Resources Conservation Service (NRCS) provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment. As part of the Acequia Rehabilitation Programs, the NRCS has been involved in the technical assistance for acequia association rehabilitations projects since 1961. Technical assistance is provided to the acequia associations is funded by OSE/ISC and typically consists of planning, design, engineering, and supervision of construction projects.

The NRCS is most interested in the AGIS as a tool to facilitate their support of OSE/ISC and acequia associations for rehabilitation projects. The NCRS does not have any automated systems that are directly applicable to the AGIS project, but would provide data captured during their planning and design efforts.

SECTION 4

PRELIMINARY DATA AND APPLICATION PRIORITIES

This section evaluates the existing geographic data resources and identifies needed improvements to existing data.

4.1 DATA REQUIREMENTS

Initial priorities for data features were developed based on the subjective evaluation of ISC, COE, HPD, and NRCS interviewees. Table 4-1 (*Data Priorities*) presents a matrix of data needs.

Table 4-1 assigns a 0, 1, 2, or 3 to each data feature based on data importance. A "0" was assigned if the data feature did not support the respective application. A "3" was assigned if the data feature was absolutely required for the respective organization. Finally, a "1" or "2" was assigned based on a subjective evaluation of the possible need of the organization for the respective data feature. For example, if a data feature would be only used infrequently, it was assigned a 1. If a data feature was not critical, but would be very helpful, it was assigned a 2. When more than one person was interviewed from an agency, the average of their ratings was used.

As can be seen in Table 4-1, all of the interviewees highly rated the need for conveyance characteristics, water rights, administrative units, and general information about the acequias. The ratings for other data features, particularly project data and culture data, varied dramatically, depending on the agency. Note that the "Features/Attributes" have been ordered according to their priority within each "Data Group."

These data requirements do not include input from acequia associations. Representatives of acequia associations have not yet been interviewed for two reasons. First, the group is large and diverse, making it costly to get a representative sample. Second, some acequia associations may not be supportive of the plan without sufficient explanation. Therefore, it is recommended that the interviews of acequia associations not be performed until the sponsoring agencies have agreed upon an approach and are ready to fully explain the AGIS purpose and benefits.

4.2 APPLICATION REQUIREMENTS

All interviewees consistently reported that the primary application requirement was for easy query and display of the identified data. It is critical that the query and display support novice and advanced users. For novice users, the system must be extremely friendly. The sophisticated users would be allowed to use all of the ESRI ARC/IMS software tools to perform complicated queries and displays. A secondary application requirement is the ability to download subsets of the data for off-line research.

Table 4-1—Acequia Geographic Information System Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
ACEQUIA SYSTEM							
	Name, Identifier	3	3	3	3	3.0	
	Status (active/inactive)	3	3	3	3	3.0	
	Boundary and/or Ditch Locations	3	3	3	3	3.0	
	National Register Status (Y/N)	3	3	1	3	2.5	
	Historic Names with dates	3	3	2	3	2.8	
	Mayordomo	3	1	3	3	2.5	Update required every two years or less.
	Date Formed	3	3	1	3	2.5	
	Contract Agent	3	1	3	3	2.5	Update required every two years or less.
	Contact Information	3	1	3	3	2.5	Update required every two years or less.
	Historic Locations w/ Dates	3	3	1	3	2.5	
	Commissioners (3)	3	1	2	3	2.3	Update required every two years or less.
	Number of Members	3	1	1	3	2.0	
ACEQUIA COMMISSION							
	Name, Identifier	2	1	2	1	1.5	
	Leadership	2	1	2	1	1.5	
	Contact Information	2	1	2	1	1.5	
	Number of Members	2	1	2	1	1.5	
	Date Formed	2	1	2	1	1.5	
							Table continued on next page

Table 4-1—Acequia Geographic Information System
Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
ACEQUIA PROJECTS							
	Evaluation Criteria	2	1	3	3	2.3	That is, number of users, irrigated acres, susceptibility to flood damage, existence of proposed construction drawings.
	Terrestrial Photographs	3	1	2	3	2.3	NRCS would like to see key photographs on-line to assit in the designs.
	Aerial Photographs	3	1	2	3	2.3	Geo-referenced project photography.
	Participants	3	1	1	3	2.0	For example, Acequia, COE, ISC, NRCS, and Contractor.
	Contact Information	3	1	1	3	2.0	
	Project Role	3	1	1	3	2.0	For example, design, construction, loan.
	Funding Level	3	1	0	3	1.8	
	EIS Number	3	1	0	3	1.8	
	Project Number	3	1	0	3	1.8	
	Project Status with Dates.	3	1	0	3	1.8	For example, Planning, Survey, Design, Construction, Certification.
	Engineering Reports	3	1	0	3	1.8	A reference to the physical location of surveys, engineering drawings, and bid package. On-line access not considered necessary.
	As Built Drawings	3	1	0	3	1.8	Note that key features may be captured from these documents as noted in other data features.
	Correspondence	3	1	0	3	1.8	A reference to the physical location.
				0			
	Project Boundary	3	1	0	3	1.8	
							Table continued on next page

Table 4-1—Acequia Geographic Information System
Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
CONVEYANCE							Note that attributes will change along the conveyance.
	Ditch Name	3	3	3	3	3.0	
	Type (e.g., Madre)	3	3	3	3	3.0	That is, Madre, Contra, Desaguas, Sobrantes.
	Status (active?)	3	3	3	3	3.0	
	Functional Condition	3	3	2	3	2.8	A ranking (e.g., excellent, fair, poor).
	Flow Capacity	3	3	3	3	3.0	
	Size (Hydraulic dimensions)	3	3	3	3	3.0	
	Ditch material	3	3	3	3	3.0	
	Drop (gradient)	3	3	3	3	3.0	Need sufficient vertical accuracy for hydraulic calculations.
	Diversion dam and headgate	3	3	3	3	3.0	Includes location and type.
	Storage ponds	3	3	3	3	3.0	
	Conveyance Location	3	3	3	3	3.0	Relative accuracy sufficient for design desired.
	Turnouts (taps) to field	3	3	3	3	3.0	
	Easements (Maint.)	3	3	3	3	3.0	Best available accuracy.
	Easements (R/W)	3	3	3	3	3.0	Survey accuracy desired.
	Flow Direction	2	3	3	3	2.8	
	Water crossings	2	3	3	3	2.8	That is, flumes, overchutes, siphons.
	Road Culverts	2	3	3	3	2.8	
	Bridges	2	3	3	3	2.8	
	Related Features	3	3	0	3	2.3	For example, Mill (molino), power generation devices.
	Previous material & dates	3	3	0	3	2.3	
	National Register Site (Y/N)	3	3	0	3	2.3	
	Maintenance regime	3	3	0	2	2.0	For example, hand, machine.
							Table continued on next page

Table 4-1—Acequia Geographic Information System
Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
ADMIN-ISTRATIVE UNITS							Existing Federal data sets, except for Related Districts.
	Counties	3	3	3	3	3.0	
	Cities	3	3	3	3	3.0	
	Related Districts	2	3	3	2	2.5	For example, Irrigation, Conservation.
	Indian Reservations	3	3	3	3	3.0	
	Federal lands	3	3	3	3	3.0	
	State Lands	3	3	3	3	3.0	
	State Lands	3	3	3	2	2.8	For example, Irrigation, Conservation.
CADASTRAL							
	PLSS	3	2	0	3	2.0	GCDB
	Parcel	3	2	0	3	2.0	Assessor data.
	Subdivision	2	2	0	3	1.8	Assessor data.
CULTURAL	CRM Reports	3	3	1	3	2.5	Summaries of Culture Resource Management (CRM) Reports are already available on-line.
	Historic Communities	3	3	0	2	2.0	
	Terrestrial Photographs	3	3	1	2	2.3	Reference to physical location acceptable.
	Videos	2	3	0	1	1.5	Note that oral histories in CRM and could be in Videos or as audios.
	Audio	2	3	0	1	1.5	
DAMS							
	Descriptive Data	3	3	2	3	2.8	Attributes contained in the National Inventory of Dams.
	Dam Safety	2	0	1	3	1.5	Attributes maintained by OSE.
							Table continued on next page

Table 4-1—Acequia Geographic Information System
Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
DIGITAL IMAGERY							
	USGS Quads (DRG)	3	3	3	3	3.0	
	DOQQs	3	3	3	3	3.0	
	Satellite Multispectrial Imagery	2	2	3	2	2.3	Data to assist in crop inventories.
	Photogrammetry	3	0	3	3	2.3	Two-foot pixels or better.
ELEVATION							
	DEM	3	2	3	2	2.5	Used for visualization and preliminary designs.
FISH AND WILDLIFE							
	Endangered Species Locations	3	0	3	3	2.3	To support EIS/EA.
GEOLOGY							Existing Federal and State sources.
	Geomorphology	2	1	1	3	1.8	
	Subsurface	2	1	1	3	1.8	
	Soils	2	1	1	1	1.3	
HYDRO-GRAPHY							
	NHDS	2	2	3	3	2.5	National Hydrographic Data Set.
	Surface Water Basins	2	2	3	2	2.3	To HUC 8
LAND USE/LAND COVER							
		1	1	1	1	1.0	Existing USGS Data Set.
TRANSPORT-ATION							
	Roads	2	3	2	3	2.5	
	Railroads	2	3	2	3	2.5	
	Addressing	1	3	1	1	1.5	
							Table continued on next page

Table 4-1—Acequia Geographic Information System
Preliminary Data Requirements

DATA GROUP	FEATURES / ATTRIBUTES	DATA PRIORITY					COMMENTS
		COE	HPD	OSE/ISC	NRCS	AVE	
WATER RIGHTS							
	Administrative Areas	3	2	3	3	2.8	
	Owner	3	2	3	3	2.8	
	Place of Use	3	2	3	3	2.8	
	Point of Diversion	3	2	3	3	2.8	
	Type of Right	3	2	3	3	2.8	
	Consumptive Use	3	2	3	3	2.8	
	Allocated Use	3	2	3	3	2.8	
	Purpose of Use	3	2	3	3	2.8	
	Source of Water	3	2	3	3	2.8	
	Priority Dates	3	3	3	3	3.0	
				3		3.0	
	Water Banking (Y/N) Arces and time frame			1		1.0	Inventory of water banking applied to specific parcels.

4.3 CURRENT RESOURCES

Many potential data sources were cursorily examined, but most of the sources are fragmented and incomplete. The most promising data resources have been catalogued and summarized in Appendix B *(Source Data)*. Existing data already stored in the OSE/ISC EGIS or in the public domain are not cataloged in this report (See the latest version of the EGIS Physical Design for detailed information). Significant data resources for conversion are defined in terms of the following attributes:

- Brief data description
- Existing data custodians
- Data format
- Rough estimate of completeness
- Rough estimate of spatial coverage
- Rough estimate of currency
- Rough estimate of accuracy (spatial and attribute)
- Rough estimate of data amount

SECTION 5

CONCEPTUAL DESIGN

The conceptual design for the AGIS is presented from two perspectives:

- Map layers
- System Architecture

Map layers are an intuitive way of thinking about physical features represented in a GIS and the descriptive data related to them. This is a useful conceptual model for thinking about map-related data management, especially for lay people.

The conceptual architecture recommends a conceptual division of analytical and transactional systems, web interfaces, and database services.

The conceptual data model identifies the additional data tables that need to be integrated into the existing databases, enabling data to be more readily shared.

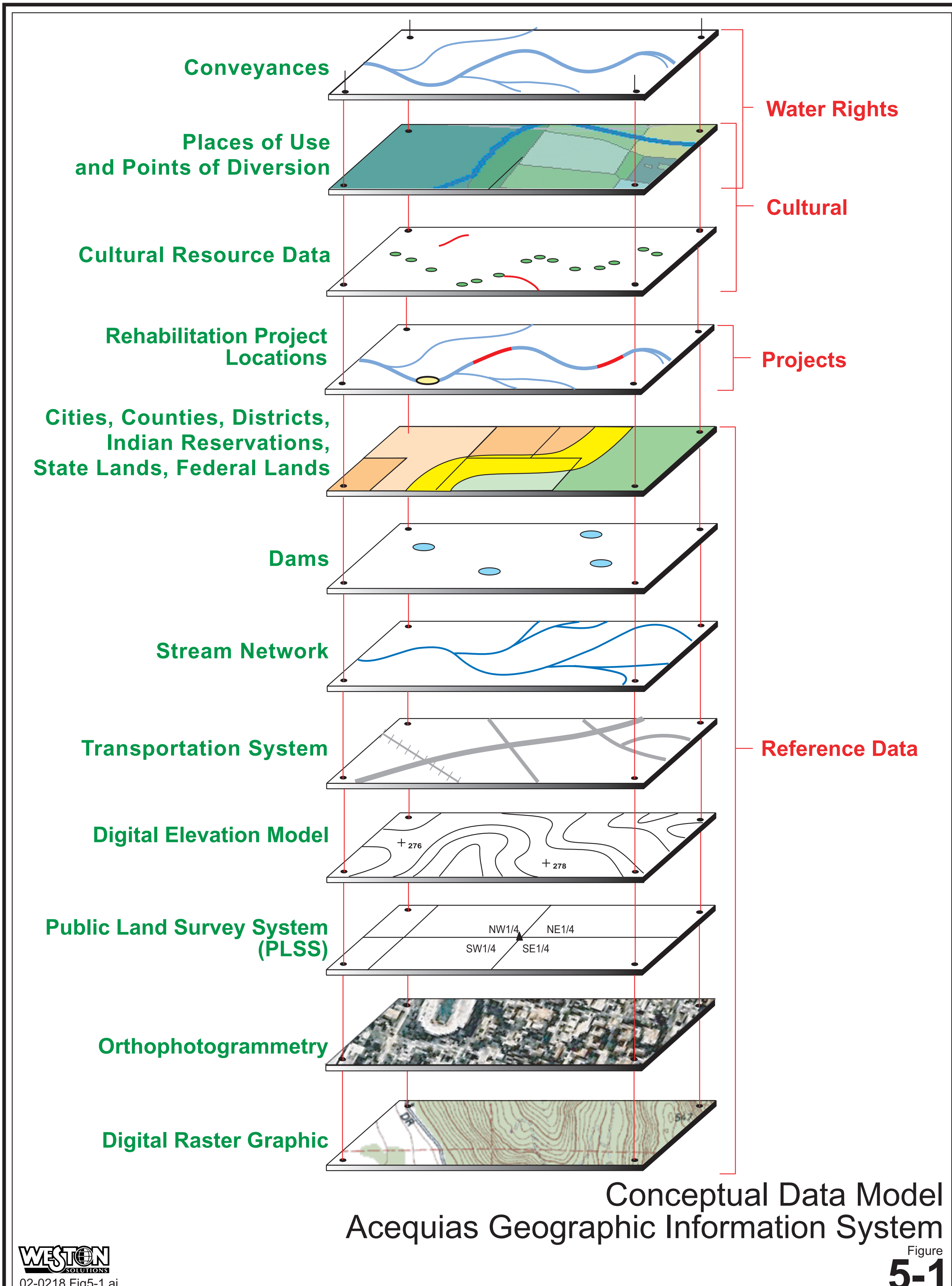
5.1 MAP LAYERS

As depicted in Figure 5-1 (AGIS Map Layers), the four generic data sets required in the AGIS are:

- Water rights associated with acequia conveyances
- Cultural and archeological information associated with the acequia and conveyances
- Project data associated with the acequias and conveyances
- Reference data to facilitate the understanding of the primary data.

Any AGIS user should be able to query any combination of data sets to produce maps and reports based on the selected data. In addition, advanced users, should be able to select and download selected data sets for off-line analysis.

For novice users, the system must be extremely friendly. In fact, it is envisioned that the user interface would provide the user with the option to generate relatively complicated queries by selecting pre-determined queries from a pull-down menu. The resulting display would also be provided in a pre-determined, standard format. This standard format would display various data features and labels depending on the content and output scale. For example, a standard query might display all acequias in a given watershed and highlight the ditches that are on the historic register and/or have planned rehabilitation projects. The system would determine the appropriate display scale given the extent of the selected features, only show the references features that are appropriate for the selected display scale, and provide a standard legend.



Conceptual Data Model
Acequias Geographic Information System

Figure
5-1

The characteristics of the system from the user's perspective are:

- User equipment needed for access will only require an Internet connection and a standard browser. No other software should be required, although an Acrobat (or equivalent) reader and image reader may be required.
- User access to some data will be restricted, based on levels of privilege to be determined.
- Response time should be minimal.
- Ditches will physically and logically connect to the State's stream system allowing queries that trace the flow of water to its source.

A two-dimensional linear spatial representation appears to be acceptable for the AGIS, as depicted in Figure 5-2 (AGIS Schematic). Most of the new attribute data will be associated with the conveyance layer. The features will be represented as points, lines, and polygons.

Point features will include related structures, photograph locations, grade change and elevation points, flow rates, etc.

Lines will represent the conveyances. Attributes that apply to a segment of the conveyance (e.g., ditch rank, condition, date built, ditch material, and historic classification, etc.) will be stored as segments. A design consideration will be the need to have lines overlay. If required, this will require dynamic segmentation, which will significantly add to the system's complexity.

The extent of the acequia will be represented by a polygon. This polygon will include the aggregation of the Places of Use associated with the ditch and/or a historically significant boundary.

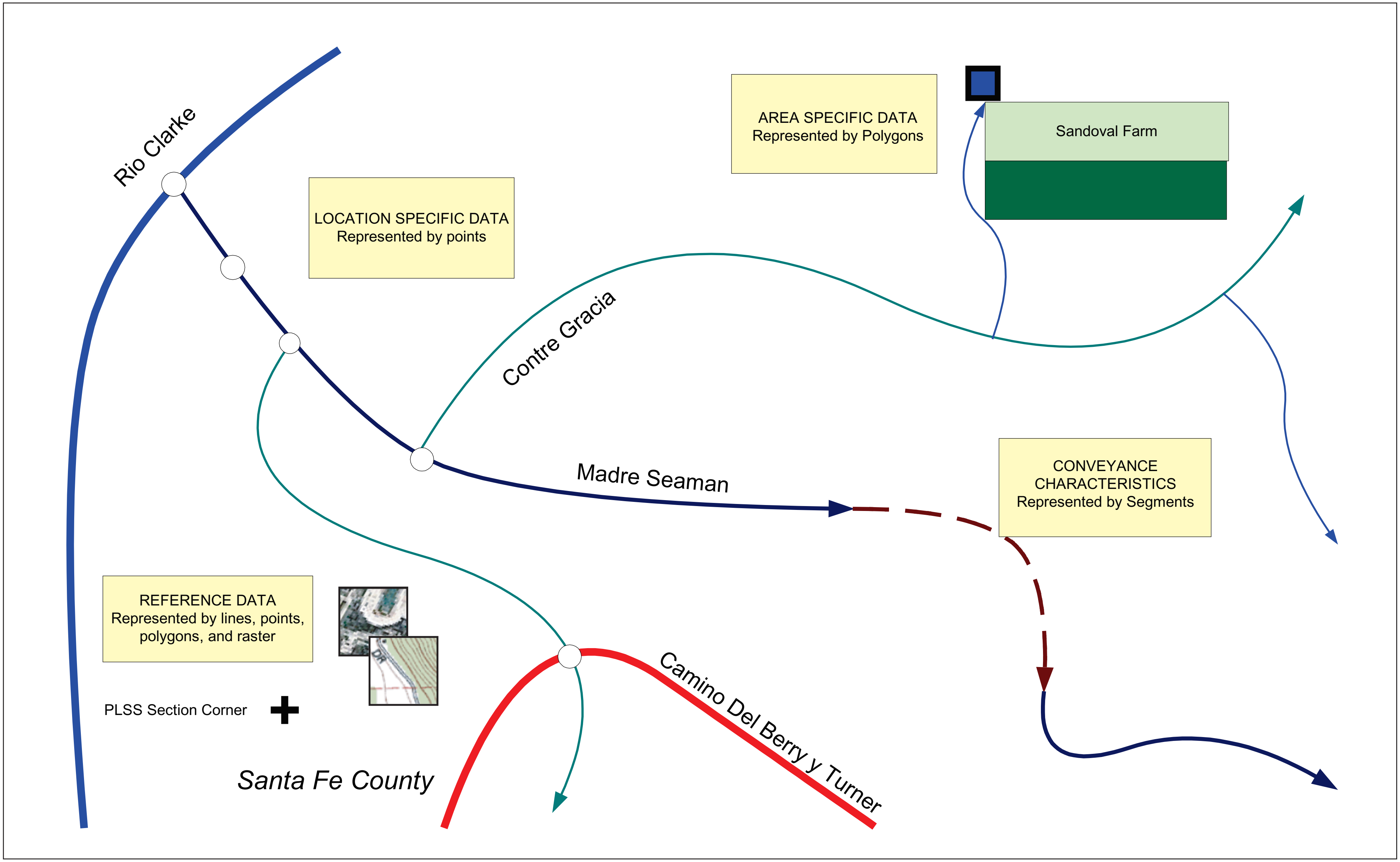
The system will use metadata that complies with the Federal Geographic Data Committee specifications. In addition, appropriate features will be attributed with feature specific attributes for spatial accuracy and source.

5.2 CONCEPTUAL ARCHITECTURE

AGIS data will mainly be managed in a geographic data warehouse with some small datasets accessed from external web data servers. The warehouse will primarily serve query and display applications. However, it will also serve some geographic data download requests.

5.2.1 Web Interface Architecture

Given the fact that most of the required data resides at OSE/ISC, the AGIS could be served solely from OSE/ISC with cultural and archeological data replicated from the NMCRIS. However, it is recommended that the AGIS should be jointly developed and maintained by OSE/ISC and HPD, although the OSE/ISC site would be the primary portal for most users.



AGIS Schematic

Figure
5-2

02-0218 Fig5-2.ai

Both agencies would provide public map services that would be accessible by the other agency's ArcIMS server. This approach would facilitate the maintenance of the data sets, with each agency being responsible for those data sets that directly support their primary missions. The individual agencies would customize their own ArcIMS web site so they can provide additional functionality to their users and limit access to sensitive data (e.g., priority dates and sensitive archeological sites) based on user logins and passwords that they control. In addition, with this recommended approach there would be no need to replicate dynamic data sets. The replication and maintenance of data between agencies is a viable option, but it would add to the overall system complexity and maintenance cost. Finally, the advanced user could log on to the agency server containing the majority of the data they would interact with, and hence improve the system response time. For instance, an archeology researcher who is only interested in archeological data (i.e., only needs to see data about acequias that are also archeological sites) would access the system through the NMCRIS site.

The proposed architecture will accommodate the possible addition of a link to a USACE site containing acequia project data.

In a typical user scenario, the user would log on to the OSE/ISC server (although users most interested in the cultural data could choose to log on the NMCRIS server). Once logged on, the system would check the users privileges and provide the appropriate access to the various data sets. The fact that the data resided on multiple machines would be transparent to the user; although, some queries would be slower if a large amount of data is requested that must be retrieved from a remote server.

The functions of the internal components are illustrated in Figure 5-3 (Potential Web AGIS Architecture). Each of these interfaces is discussed below.

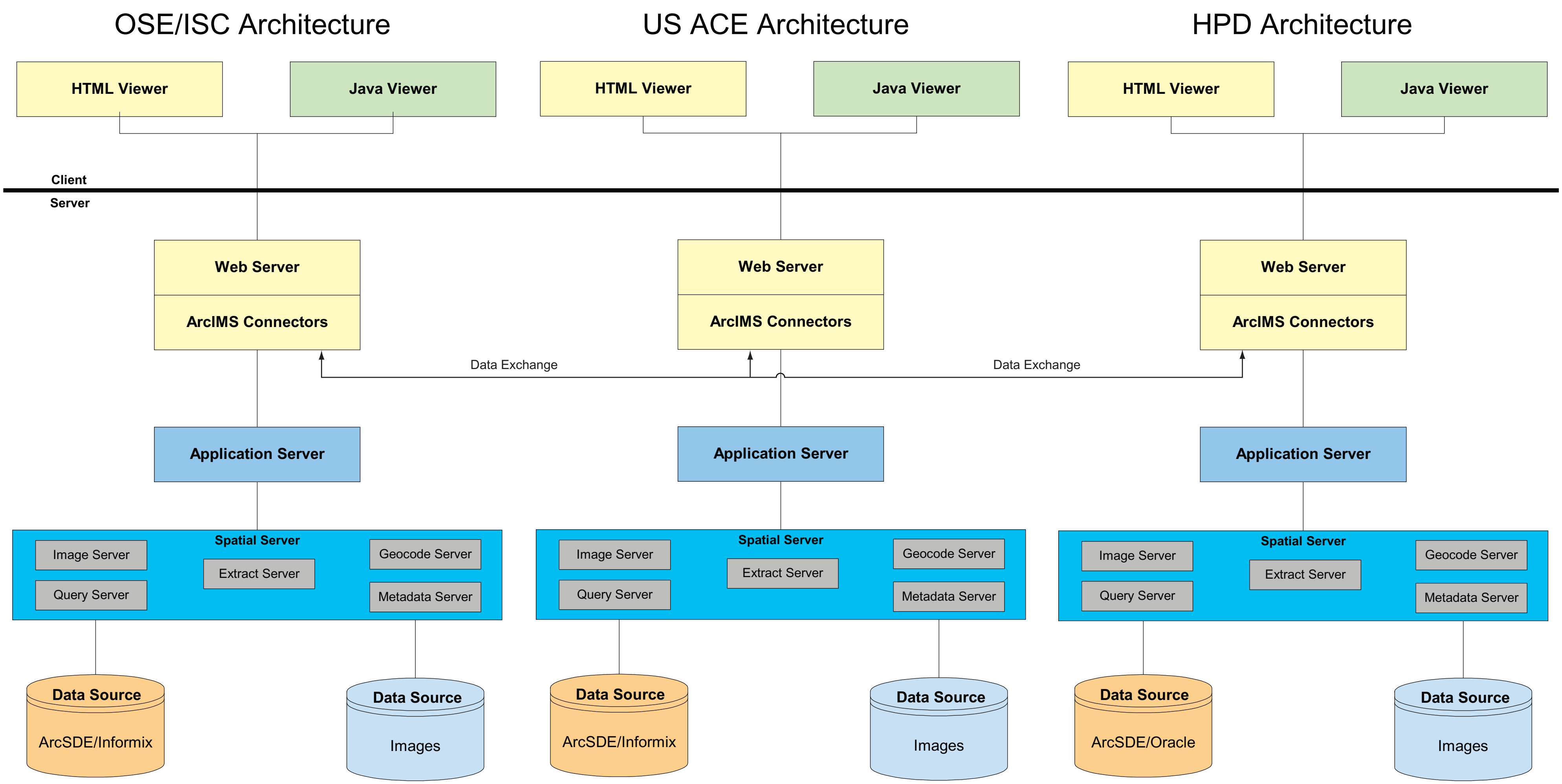
ArcIMS Web Server

ArcIMS will be the main tool for viewing the AGIS data. The interface will perform the following functions:

- Query & display
- Geocoding
- Metadata browsing
- Display data from external sources
- Extract data from the geodatabase

Query and display are the main uses of this interface. It is assumed that this server will be ArcIMS 4.0 or higher. The users will perform queries using a customized HTML or Java Viewer that is served through the Web Server. The ArcIMS ActiveX connector will manage access to an external data store on the other host agency's ArcIMS server(s).

Geocoding will be processed through the Spatial Server and is necessary so users can quickly locate areas of interest.



Potential Web AGIS Architecture

WESTON SOLUTIONS

Figure
5-3

02-0218 Fig5-3.ai

Metadata will be stored in the geodatabase and will be viewable through the ArcIMS viewer. Users will also be able to perform searches on the metadata based on any combination of geographic extent, content type, data format, or keyword.

It is envisioned that there will be initially two ArcIMS Web Servers—one at OSE/ISC and one at HPD. A future Web Server might be located at USACE. Each Server will serve the data stored locally and will be able to access data being served by the other server. Only the data that is specifically being publicly served will be accessible to each server so public access to sensitive data is not a concern.

Through the interface, advanced users will be able to extract and download data from the geodatabase and for advanced analysis. This functionality will be protected by a login/password so only authorized users will be able to download authorized data.

5.2.2 Database Services

The proposed conceptual architecture assumes GIS data is stored in a geodatabase. A geodatabase is a geographic database that resides inside a relational database management system (RDBMS) that provides services to manage the geographic data. For the AGIS, the geodatabase is stored in RDBMSs such as Informix or Oracle and accessed via products such as ESRI's ArcSDE. There are several reasons why the AGIS data should be in a geodatabase:

- A geodatabase query is extremely fast and provides a means to share data in different RDBM.
- Geographic data layers are continuous in a geodatabase and not split into separate geographic units.
- Many users can edit geographic data simultaneously because the geodatabase supports feature locking.

Both OSE/ISC and HPD are migrating to geodatabases using ESRI's Spatial Database Engine (ArcSDE) Version 8.x. Therefore, despite the fact each agency uses a different database (Informix Dynamic Server for OSE/ISC and Oracle for HPD), sharing of the data will not be an issue. It has been suggested that Oracle Spatial be used instead of ArcSDE. This is a viable option since a properly tuned installation of Oracle Spatial is faster then ArcSDE using Oracle, but implementing ArcIMS with direct connects to Oracle Spatial is not nearly as easy to implement as ArcIMS connecting directly to ArcSDE. Ultimately, the decision to migrate the local ArcSDE data to Oracle Spatial rests with HPD and will not affect the conceptual AGIS design.

5.2.3 Conceptual Data Distribution Model

The AGIS is actually a sharing of data between existing systems. Therefore, the data architecture for common tables will have to be coordinated between agencies. Fortunately, it appears that the data models of the existing systems will remain essentially the same with respect to tables, relationships, and attributes. This sub section recommends the physical location of the required data.

5.2.3.1 Conveyances and Water Right Information

The existing OSE EGIS design contains all of the required reference layers, all of the relevant water right data (e.g., Place of Use, Point of Diversion, owner, priority date, etc.), and some of the conveyance data identified for the AGIS; however, only the ditch name and direction of flow are readily available from OSE hydrographic surveys. The EGIS also contains an Acequia Table. The remaining attributes associated with the conveyances can be easily added to a subsequent EGIS physical design. The major issue will be the collection of the desired feature attributes, as discussed in Section 6.

The water rights and conveyance data change daily as changes to water right applications are approved and implemented. In addition, the long-term maintenance of the water rights data must be done by OSE/ISC and the maintenance of the conveyance is best done by OSE/ISC in the process of hydrographic surveys and water use and conservation studies. Of course, additional data will have to be collected at a marginal cost.

5.2.3.2 Reference Layers

The reference layers that have been identified for the AGIS are already being maintained by the OSE EGIS to support the agency's water resource management mission. Therefore, it is recommended that OSE/ISC maintain and serve this data.

5.2.3.3 Cultural Information

The update, maintenance, and distribution of cultural and archeological data are the functions of the HPD. Some of the data maintained by HPD are restricted (e.g., sensitive archeological sites). It is recommended that these data be maintained in the NMCRIS. Although data replication is possible, it would result in higher system maintenance costs. In addition, the possibility of accidentally distributing restricted archeological data may be unacceptable.

5.2.3.4 Project Data

The project data is mostly desired by USACE and NCRS to support the engineering function. Therefore, it is recommended that these project data be maintained by these groups.

SECTION 6

IMPLEMENTATION PLAN

This section recommends an implementation strategy, schedule, budget and cost for system development.

6.1 IMPLEMENTATION APPROACH

An iterative, phased, implementation process is recommended. Given the number of potential users, it is not reasonable to sequentially define the entire problem, design the entire solution, build the software, convert the data, and finally test the product. An iterative approach is required that allows an increasing understanding of the problem through successive refinements, and to incrementally grow an effective solution over multiple iterations. This approach gives better flexibility in accommodating new requirements or tactical changes in business objectives, and allows the project to *identify and resolve risks* earlier.

The Rational Unified Process for software engineering along with the Unified Modeling Language (UML) are recommended for specifying, visualizing, constructing, and documenting the artifacts of the software system.

The major phases are:

- Elaboration
- Construction
- Transition
- Operation and maintenance

Each of these phases is discussed below.

6.1.1 Elaboration Phase

The purpose of the elaboration phase is to analyze the problem domain, establish a sound architectural foundation, develop the project plan for the construction and transition phases, and eliminate the highest risk elements of the project.

The outcome of the elaboration phase is:

- A completed requirements definition
- A glossary of important terms that will be used in the project
- Domain model
- Data model
- User-interface design
- A preliminary users manual
- Finalize tools and development environment

- A software architecture document
- A prototype project to test the system design and conversion procedures
- A project plan for the remaining phases

In order to effectively complete the elaboration phase, at least three full-day workshops would be needed to finalize the system design. All key participants, including acequia representatives, should be involved in each workshop.

6.1.2 Construction Phase

The construction phase will follow the elaboration phase. The purpose of the construction phase is to iteratively develop a system ready for transition into the user community. The following subtasks for each release will be performed:

- Develop iteration plan
- Prepare detailed designs
- Incrementally build the AGIS
- Perform staged data conversion
- Conduct unit and integration testing
- Release the latest build (alpha, pre-beta, or beta)
- Revise the user documentation
- Assess the iteration

The outcome of the construction phase is a beta product ready to be put in the hands of its end-users.

6.1.3 Transition Phase

The transition phase would occur during the construction phase once sufficient data was available to go 'live.' The purpose of the transition phase is to transition the AGIS to the user community. This phase starts with a beta test period in which the beta release of AGIS is given to a small and well-known set of users, who are forewarned about the maturity of the product they receive, and are required to return feedback on its functionality and usability. Once the system has been given to the end user, issues will arise that require developing new releases, correcting some problems, or finishing some of the features that may have been postponed.

The major tasks of this phase are:

- Set up beta-test environment
- Install AGIS beta release
- Enhance beta to production release
- Install AGIS production release
- Train users
- Perform acceptance testing
- Prepare and perform cutover
- Support system during the critical period

The outcome of this subtask is a fully operational system and completed documentation.

6.2 COSTS

Based on the conceptual AGIS design and identified data requirements, rough cost estimates have been prepared to provide decision makers with sufficient information to decide if the AGIS should: 1) proceed to the elaboration phase; 2) be refined; or 3) be rejected. It must be remembered that these “order of magnitude” cost estimates are based on incomplete information that must be refined during the elaboration report.

Table 6-1 (AGIS Cost Estimates) provides the best available cost estimates at this time. The data conversion costs represent the overwhelming majority of the total cost. These conversion costs are driven by the desired spatial accuracy and data completeness (does every historic conveyance have to be mapped?). These conversion costs will vary considerably depending on the number of features to be converted and the development approach. Therefore, a range of cost is provided. The comments column of Table 6-1 (AGIS Cost Estimates) provides reasons for the cost variances and other salient assumptions.

Table 6-1 - AGIS Cost Estimates

Category		Low Cost Estimate			High Cost Estimate			Explanation of Estimate Variance and Assumptions
		Units	Unit Cost	Low Estimate	Units	Unit Cost	High Estimate	
Elaboration Phase								
Finalize requirements, logical design, and physical design.		1	$ 50,000	$ 50,000	1	$ 75,000	$ 75,000	The low estimate assumes only three workshops and general agreement among participants, while the high estimate assumes five workshops and considerable "selling" efforts to reach agreement.
Prototype Development		1	$ 50,000	$ 50,000	1	$ 100,000	$ 100,000	The low estimate assumes a relatively small pilot area selected based on availability of existing data, while the high estimate assumes a significant data collection effort.
Project Coordination at	15%			$ 15,000			$ 26,250	
Contingency at	15%			$ 17,250			$ 30,188	
Sub Total				**$ 132,250**			**$ 231,438**	
Construction Phase (not including conversion)								
Application Development		1	$ 35,000	$ 35,000	1	$ 70,000	$ 70,000	The low estimate assumes minimal efforts to provide standard queries, while the high estimate assumes a complete set of desired canned queries.
System Installation		1	$ 10,000	$ 10,000	1	$ 40,000	$ 40,000	The low estimate assumes minimal changes to existing hardware and software equipment and configurations, while the high estimate assumes the new configuration of purchased of hardware and software.
Project Coordination at	15%			$ 6,750			$ 16,500	
Contingency at	15%			$ 7,763			$ 18,975	
Sub Total				**$ 59,513**			**$ 145,475**	
Construction Phase (Conversion)								
Existing Ditch Source Documents								
Hydrographic Surveys (hardcopy), linked to WATERS		1,000	$ 440	$ 440,000	3,200	$ 440	$ 1,408,000	The low estimate assumes conversion of only those historic hydrographic surveys that would not normally be converted by OSE. The conversion of all other surveys are done by OSE as needed. The high estimate assume that all surveys are converted according to the AGIS schedule. Both cost estimates assume that all features are converted according to the EGIS specifications.

Table continued on next page.

Table 6-1 - AGIS Cost Estimates

Category		Low Cost Estimate: Units	Low Cost Estimate: Unit Cost	Low Cost Estimate: Low Estimate	High Cost Estimate: Units	High Cost Estimate: Unit Cost	High Cost Estimate: High Estimate	Explanation of Estimate Variance and Assumptions
Hydrographic / ditch Surveys (GIS, but non EGIS format)		0	$ 200	$ -	200	$ 200	$ 40,000	The low estimate assumes that the conversion of electronic hydrographic surveys will be done by OSE on a schedule that meets the AGIS needs. The high estimate assume that all surveys are converted under the AGIS schedule. Both cost estimates assume that all features from recent adjudications and irrigation district GISs are converted according to the EGIS specifications.
E-size Design Drawings		60	$ 70	$ 4,200	120	$ 60	$ 7,200	The low estimate assumes that a review of the known drawing will show that only half have sufficient information to justify the conversion effort. It is further assumed that each project averages four drawings.
Material Handling at	5%			$ 22,210			$ 72,760	
Project Coordination at	15%			$ 69,962			$ 229,194	
Contingency at	15%			$ 80,456			$ 263,573	
Subtotal				**$ 616,827**			**$ 2,020,727**	
Statewide Ditch Inventory from Statewide Mapping								
Digitize Undocumented Acequias assuming 5 miles of ditches per acequia		800	$ 150	$ 120,000	2,000	$ 120	$ 240,000	The low estimate assumes that only registered acequias will be delineated, while the high estimate assumes that attempts will be made to map all known acequias (existing and extent). The source for mapping would be either DOQQs or new statewide mapping.
Material Handling	10%			$ 12,000			$ 24,000	
Project Coordination	15%			$ 19,800			$ 39,600	
Contingency	15%			$ 22,770			$ 45,540	
Sub Total				**$ 174,570**			**$ 349,140**	
Desk top attribution from various sources								
Research and attribute acequia from miscellaneous historic documents. Cost per document.		75	$ 135	$ 10,125	1,200	$ 100	$ 120,000	The low estimate assumes that only the 75 documents known to have specific acequia information are used for the attribute capture, while the high estimate assumes all possible documents will be investigated.
Material Handling at	15%	100		$ 1,519	100		$ 18,000	
Project Coordination at	15%			$ 1,747			$ 20,700	
Contingency at	25%			$ 3,348			$ 39,675	
Sub Total				**$ 16,738**			**$ 198,375**	

Table continued on next page.

Table 6-1 - AGIS Cost Estimates

Category		Low Cost Estimate			High Cost Estimate			Explanation of Estimate Variance and Assumptions
		Units	Unit Cost	Low Estimate	Units	Unit Cost	High Estimate	
Field Surveys								
Collect missing acequia data on-site. Cost per acequia.		800	$ 600	$ 480,000	1,600	$ 600	$ 960,000	The low estimate assumes that only registered acequias will be visited, while the high estimate assumes that 1,600 acequias will be identified that required field investigation. It is also assumed that one person can average two acequias per day and that meter level spatial accuracy will be sufficient.
Data Management	10%			$ 48,000			$ 96,000	
Project Coordination at	15%			$ 79,200			$ 158,400	
Contingency at	25%			$ 151,800			$ 303,600	
Sub Total				**$ 759,000**			**$ 1,518,000**	
Miscellaneous Data Entry								
Geo-rectified Aerial Photographs		0	$ -	$ -	1000	$ 25	$ 25,000	The low estimate assumes that no historic aerial photographs are geo-rectified, while the high estimate assumes 1,000 historic aerial photographs are geo-rectified.
Referenced Terrestrial Photographs		500	$ 5	$ 2,500	5,000	$ 5	$ 25,000	The low estimate assumes that only 500 terrestrial photographs are referenced in the AGIS as point data, while the high estimate assumes 5,000 photographs.
Video and/or Audio		0	$ 3	$ -	100	$ 3	$ 260	The low estimate assumes that no video or audio files are referenced in the AGIS as point data, while the high estimate assumes 100 such files. It is also assumed that the audio and/or video are existing files.
Material Handling at	10%			$ 250			$ 5,026	
Project Coordination at	15%			$ 413			$ 8,293	
Contingency at	25%			$ 791			$ 15,895	
Sub Total				**$ 3,953**			**$ 79,474**	
Grand Total				**$ 1,762,851**			**$ 4,542,628**	

6.3 SCHEDULE

Figure 6-1 (Project Schedule) provides one of many possible schedules. The Elaboration phase is estimated to take from six months to a year and includes a prototype development. At the end of the prototype, the AGIS design would be modified, based on the experience learned during the prototype. A yearlong elaboration phase has been assumed to be conservative. The construction phase could range from a year to many years depending the available resources. An efficient construction schedule is estimated to be two years. Finally, the transition phase would occur during the construction phase once sufficient data was available for distribution.

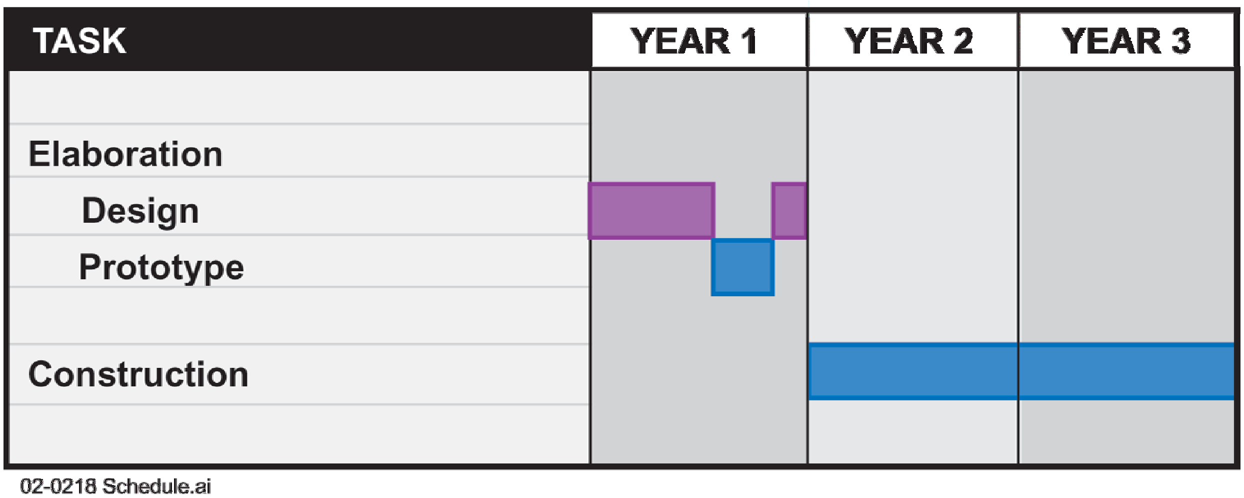


Figure 6-1—Project Schedule

SECTION 7

REFERENCES

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APPENDIX A

INTERVIEWEES

APPENDIX A

INTERVIEWEES

Ackerly, Neal W., Ph.D., Dos Rios Consultants, Inc., Silver City, NM

Berry, Neal, GIS Manager, New Mexico Historic Preservation Division

Kneebone, Ron, Ph.D., Former Project Manager, Acequia Restoration and Rehabilitation Program, USACE.

Garcia, John, Title, Office of the State Engineer / Interstate Stream Commission

Leiting, Ken, Natural Resource Conservation Service

Mathers, Clay, Ph.D., GIS Manager, USACE

New Mexico Office of the State Engineer, Geographic Information Systems Technical Team

Pacheco, David, State Conservation Engineer, Natural Resource Conservation Service

Sandoval, Levi, District Conservationist, Natural Resource Conservation Service

Seaman, Tim, ARMS Program Manager, New Mexico Historic Preservation Division

Turner, Bob, Database Manager, New Mexico Historic Preservation Division

Van Citters, Karen, Preservation Consultant, Van Citters Historic Preservation, LLC

APPENDIX B

INVENTORY OF SOURCE DATA

APPENDIX B

INVENTORY OF SOURCE DATA

Description
Research project titled: A Review of the Historic Significant of and Management Recommendations for Preserving New Mexico's Acequia Systems.
Data Format
Report with ACCESS database
Custodian
New Mexico Office of Culture Affairs, Historic Preservation Division (HPD)
General Contents
The database contains the most recent inventory of 2,048 acequias in New Mexico. The attributes are: Hydrological unit, County, river/stream, ditch name, date built, location data in the PLSS, State Plane Coordinates, and Source Documents.
Spatial Coverage
State of New Mexico. See Figure 2-4 for a graphical distribution of the acequias.
Purpose
Prepared as part of a study done by Dos Rios Consultants (Neal Ackerly) for HPD on an overview of the history of irrigation in New Mexico.
Completeness
This inventory appears to be the most complete inventory available. The following database attributes are only partially complete: Ditch name (5 missing records), Date Built (900 missing records,), Location Data PLSS (1,473 missing records), State Plane Coordinates (1,960 missing records), and Source (76 missing records).
Currency
Inventory published in 1996.
Accuracy (spatial and attribute)
Most of the spatial records are missing and there is some inconsistency between streams, hydrological units, and counties. However, this appears to be the most accurate source available.
Size of Data Set
2,048 records, each record covers one community ditch.

Description
USACE Acequia Projects
Data Format
Hardcopy and various digital formats: [DGN (4) , DjVu (2) , Jpeg (47), MrSid (27), PDF (190), geo-rectified TIFF (24), and raw TIFF (201)].
Custodian
U.S. Army Corps of Engineer, 4101 Jefferson Plaza NE, Albuquerque, NM 87109 Phone (505) 342-3255.
General Contents
NRCS maps, project documents, aerial photographs, ground photographs, DOQQs, and DRGs.
Spatial Coverage
Digital copies covers 21 acequia projects and approximately 29 acequia projects in hardcopy going back to 1987.
Purpose
Acequia rehabilitation project documentation.
Completeness
The files are apparently complete. Unfortunately, most (if not all) drawing used an assumed horizontal and vertical datum.
Currency
All projects back to 1987 are apparently available.
Accuracy (spatial and attribute)
Sufficient for design purposes.
Size of Data Set
Approximately 50 project. Approximately 29 projects are hardcopy and the remaining 21 projects in digital format contain 468 files in the following formats: DGN (4), DjVu (2), Jpeg (47), MrSid (27), PDF (190), geo-rectified TIFF (24), and raw TIFF (201). There are 11 projects with a total of 85 NRCS maps, 12 projects with a total of 145 miscellaneous documents, 2 projects with a total of 21 historical aerial photographs, 5 projects with DOQQs, and 1 project with 23 ground photographs. Miscellaneous files contain thousands of terrestrial photographs and over one megabit of digital photographs.

Description
NRCS Design Documents
Data Format
Hardcopy
Custodian
Levi Sandoval, NRCS. All drawing should be on file with the ISC.
General Contents
Acequia plans, specifications, and related reports.
Spatial Coverage
Statewide, but most of the projects are in the Northern Rio Grande.
Purpose
Engineering for the rehabilitation of acequias.
Completeness
Complete for project that NRCS provided design services.
Currency
Current as of the date of design. Unfortunately, these are not as-built drawings.
Accuracy (spatial and attribute)
Sufficient for engineering design. Unfortunately all of the drawings use an assumed horizontal and vertical datum.
Size of Data Set
Approximately 12 projects per year averaging four design drawings per project.

Description

Major Canals, Drains, and Ditches

Data Format

Digital Arc/Info Coverages

Custodian

Middle Rio Grande Conservancy District's (MRGCD), GIS Department (1931 Second Street SW, Albuquerque, NM 87102-4515, phone: 505-247-0234)

General Contents

These data represent the centerlines of the major hydrological conveyances only. Some minor ditches have been included if the data were available. Examples of data attributes included: Ditch Name and older or uncommon names, station location numbers, surface elevations, bottom elevations (as designed), various parameters (such as: slope, discharge, bottom width, operating width at the surface, operating depth), luclass (Bureau of Reclamation classification-1992), and waste way or culvert size.

Spatial Coverage

This data set represents the water conveyance (facility) data layers for each of the MRGCD's four divisions: The Cochiti Division, Albuquerque Division, Belen Division, and Socorro Division.

Purpose

The digitizing work is the result of a cooperative effort between OSE (Hydrology Bureau) and the New Mexico District of the USGS (Water Resources Division). The work was originally started to provide ancillary data to a ground-water model being constructed by the USGS.

Completeness

Data was incorporated into the GIS as described from the MRGCD's engineering "Plan and Profile Sheets". Some of the facilities were pre-existing (prior to the formation of the MRGCD) and therefore no Plan and Profile Sheet data exists

Currency

No attempt was made to create a comprehensive GIS data library other than to account for the existing data available at the time, from the 1930's Plan and Profile Sheets and any newly discovered data related to the model's efficiencies. The data is updated by the MRGCD as resources are available.

Accuracy (spatial and attribute)

The data was created from USGS Digital Ortho Photo Quad, (DOQQs) based on 1999 aerial photography, and engineering drawing TIF files. Arc Vectors were digitized on screen. Because of DOQQ overlap and spatial warping, the centerlines of the conveyances should be considered to be a generalized location.

Size of Data Set

Four coverages, the largest being 0.5 MB.

Description
Miscellaneous documents
Data Format
Hardcopy reports and maps.
Custodian
See Ackery (1996:170-250) and the companion Access database.
General Contents
All aspects of acequia history.
Spatial Coverage
State wide.
Purpose
The reports consist of court decrees, hydrographic survey reports, historical records, cultural reports, federal agency reports, and other miscellaneous topics associated with acequias.
Completeness
This list might not be complete, but it is probably the most reliable list of relevant documents associated with acequias.
Currency
These are all historic documents.
Accuracy (spatial and attribute)
Unknown.
Size of Data Set
Approximately 1,200 documents, of which at least 75 are known to contain relevant information.

Description
Design Documents
Data Format
Hardcopy
Custodian
Office of the State Engineer / Interstate Stream Commission, Bataan Memorial Building, 407 Galisteo Street, Santa Fe, New Mexico 87501
General Contents
Acequia plans, specifications, and related reports.
Spatial Coverage
Statewide, but most of the projects are in the Northern Rio Grande.
Purpose
Engineering for the rehabilitation of acequias.
Completeness
Most of the designs are not referenced to a coordinate system and use an assumed datum.
Currency
The design drawings are not necessarily as-built and are only valid as of the design date.
Accuracy (spatial and attribute)
Sufficient for engineering design.
Size of Data Set
Undetermined.

Description
Hydrographic Surveys
Data Format
Hardcopy and electronic
Custodian
Office of the State Engineer / Interstate Stream Commission, Bataan Memorial Building, 407 Galisteo Street, Santa Fe, New Mexico 87501
General Contents
Conveyances, Places of Use, and Points of Diversion.
Spatial Coverage
Statewide.
Purpose
Adjudication of water rights.
Completeness
Complete for adjudication purposes; however, the only attributes associated with the ditches are name, which is not necessarily definitive.
Currency
The surveys are only valid for the date surveyed. Changes since the survey can be determined from filing maps filed with the Water Rights Division.
Accuracy (spatial and attribute)
Sufficient for adjudication, typically at a mapping scale of 1" = 300 feet.
Size of Data Set
Over 3,000 surveys. Hard copy: Animas—26, Bluewater—38, Carlsbad—158, Canadian River—195, Gila-San Francisco—112, Lower Rio Grande—9, Mimbres Valley—208, Portales—608, Rio Grande—538, San Juan—144, San Simon—10, Tularosa—11, Upper Pecos—69, Undeclared basins—55. Digital surveys (EGIS Format): Fort Sumner—7, Roswell—??, Hondo—95 (in process), Penasco—51 (in process). Digital format (GIS): Nutt-Hockett—22, Lower Rio Grande—71 (does not include domestic surveys), Carlsbad—158 (in process), Chama—100.

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